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INHERITANCE OF MAMMÆ IN DUROC JERSEY SWINE

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THE relative fixity of character and definite methods of variation in the mammæ of swine make them a fruitful field for inheritance studies. The observations incorporated into this paper were made upon swine used in a feeding experiment at the Iowa State College. There were fifty-seven grade Duroc Jersey sows and five hundred and ten pigs of 1912 farrowing included in the investigation.[1]

The sows may be divided into two groups, one of forty two-year-old animals and the other of their yearling daughters, seventeen in number. In all, there are three generations for comparative study, a rare combination in such numbers among ordinary slow-breeding farm animals. There were two boars in use in the experiment, one a yearling, the other a two-year-old, both closely related as ordinary pedigree breeding is considered. From the standpoint of mammæ pattern, the boars were quite similar somatically, the only difference being that the asymmetry present occurred on opposite sides in the two animals. In the older boar the right nipple of the second pair was not developed, and in the younger boar the left nipple of the same pair was suppressed.

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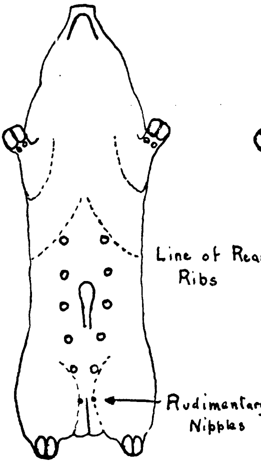
[1] The writer wishes to make acknowledgments to Professor John M. Evvard, of the Iowa Station, for the facilities he put at the writer's disposal and to Mr. A. R. Chappel, a senior student, for great assistance in the collection of data. But most of all, acknowledgments must be made to Dr. Castle, of Harvard University, for his assistance in the study of the data while the writer was working up his material at the Bussey Institution.

I.



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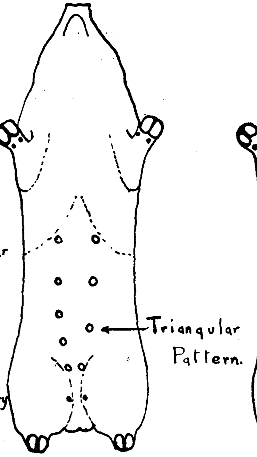

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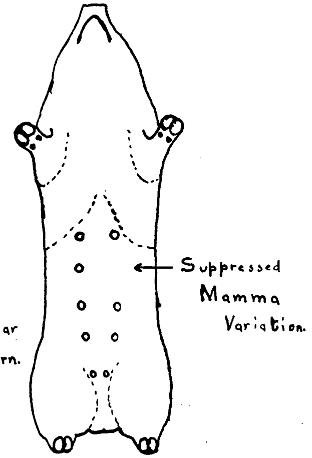

The Mammæ Pattern.—What may be termed the "normal" mammæ pattern consists in the occurrence along the ventral side of regularly placed pairs. The first pair lies just behind the junction of the ribs with the sternum. The last pair is inguinal in position, and its members lie close together near the median plane. The intermediate pairs are spaced about equally between, although a slightly greater distance separates the last two pairs. In the male with ten mammæ (five pairs), the sheath opening lies between the second and third pairs, while the fourth pair is about the same relative distance to the rear of the third. In the female the nipples are similarly placed, but less readily located in a definite manner, because of the absence of the sheath.

It has been assumed by some writers that the paired mammæ bear a relation to the metameric structure of the individual. Williams particularly contends for this view, claiming that each somite in the original ancestral condition possessed its pair of glands. He also invokes the theory of reversion to account for the definite places in which supernumerary nipples occur. Bateson, on the contrary, defines the position of the teats as occurring regularly on the "mammary lines." These lines diverge toward the axillæ and converge toward the inguinal region. He assumes that mammæ may appear at any point on these lines and apparently with only slight relationship to the somites.

Embryology.—Embryologically, Bateson's idea of the mammary lines seems to be well supported. In the swine embryo of 14–15 mm. the mammary ridges appear plainly visible in a dorso-lateral position. At about 17 mm. small elevations ("primitive teats") appear on the surface of these ridges. When about 19–20 mm. long, the intervening parts of ridges are resorbed, leaving the teats at the point in which they will normally develop.

This entirely precedes the formation of the true mammary tissue. In fact Creighton says that in the kitten the latter may not appear until after birth, although guinea pigs and swine show an earlier development. The factors that govern the transverse division of the lateral mammary tissue into mammæ, so far as the writer has been able to discover, are unknown. Most authors have insisted that metamerism has nothing to do with it, but offer little demonstrable in its place. Suffice it to say, however, there is some force that serves to maintain symmetry and regularity of division in the majority of cases. An attempt will be made to show some of its effects in the following study, even though it can not be definitely named and its action described.

Types of Variation.—The simplest type of variation in the number of mammæ consists of one more or one less pair than is the usual number. The writer has assumed the first pair and the inguinal pair constant, because of their definite position. On this assumption, the addition or substraction of a pair of mammæ must occur at some intermediate point. If a pair is added, it may be associated with a closer spacing of the teats, or possibly with a greater body length from the tip of the sternum to the border of the groin. If subtracted, the opposite condition would obtain. No observations were made on this point, and indeed it would be difficult to make them, because of the elastic nature of the tissue, the difficulty in handling the animals, and their marked variability in size and proportions.

There are two common sorts of asymmetry that may occur separately or together. These are the "suppressed nipple" and the "triangular" patterns. The former consists in the non-appearance of one member of a pair, while the latter shows one teat placed opposite two teats on the other side. The single teat is located at a point midway between the opposite two, and is always on the mammary line. The suppressed mamma variation appeared in 29.8 per cent. of the offspring and the triangle in 21.7 per cent.

The suppressed mamma variation may occur twice in the same animal, either on the same or opposite sides of the body, the two sorts of repetition being about equally frequent. But whenever the variation is repeated on the same side of the body, a normally placed pair of mammæ always intervenes. Less frequently a pair of mammæ seems to be omitted altogether, leaving an empty space where normally a pair of mammæ would occur. This may be interpreted as the suppression of two mammæ on opposite sides in one pair. The writer is rather doubtful of this interpretation, however, and does not include it in the 29.8 per cent. already mentioned. The omission of a pair was found in only 5 cases, or less than 1 per cent. of all.

The triangle pattern shows three or perhaps four types of compounding. Two triangles may appear with the single nipples on the same side and separated by one or more normal pairs, or they may be separated similarly, but have the single nipples on opposite sides. The third type is where no normal pair divides the two triangles and two mammæ on one side balance three on the other. In this case, where more than two triangles are present, three nipples on one side may balance four opposite or four may balance five. This last condition occurred in only two cases. The fourth type is doubtful and difficult to describe. It is as though the two triangles have their bases on opposite sides of the animal, but have one side in juxtaposition with the corresponding side of the other. In other words, two of the mammæ form the sides of two oppositely facing triangles and give a two-balancing-two effect. The mammæ on one side are opposite a point intermediate between those on the other. This effect may possibly be brought about by a combination of the suppressed nipple and triangle type as well. In seven individuals the triangle and suppressed nipple were found on the same animal, separated by one or more normal pairs.

There sometimes appears a pattern in which the mammæ of one side are set ahead of the points where they commonly occur, as though one lateral row were pushed slightly forward. This may be characteristic of the entire mammary series or of only one or two pairs. The arrangement is seldom so distorted that the identity of the pairs is lost, but occasionally it approaches the fourth compound type of triangle just discussed. A suggestion has been offered that this distortion may be due to the position of the fetus during pregnancy, so that when the abdominal walls grow together, the mammæ do not lie exactly opposite. An objection to this is that not only would the abdomen show the asymmetry, but also the ribs and sides. No observations were made on this point, but to the writer the explanation offered seems doubtful.

The Seat of Greatest Variation.—For convenience in description, the pairs of mammæ may be numbered from the most forward pair to the rear. Considering the first pair and inguinal pair as constant, the mammæ of the intervening region were tabulated by number. This method, of course, made the fifth and sixth pairs of much lower frequency than the other five, since so many animals had but ten mammæ. In figuring percentage frequencies for each position the total number of mammæ possible in all of the animals, if each had a pair in the position under consideration, was used as a basis for computation. The columns 1½, 2½, etc., show the frequencies of mammæ forming the apex of a triangle, in the position between pairs 1 and 2, 2 and 3, etc.

The total number of mammæ for each position which could occur if there were no variations is 1,138 for the first four and inguinal pairs. The constancy of the last named pair is particularly marked, only nine variations obtaining.

	Pair						
	1	1½	2	2½	3	3½	4
No. nipples	1,112	25	989	37	1,088	14	1,095
Per cent. frequency mammæ	97.715	2.2	86.906	3.25	95.606	1.23	96.221
Per cent. frequency variations	2.285		13.094		4.394		3.779

	Pair					
	4½	5	5½	6	6½	Inguinal
No. nipples	19	649	28	127	7	1,129
Per cent. frequency mammæ	2.7	92.187	16.09	72.987	4.023	99.209
Per cent. frequency variations		7.813		27.013		0.791

Arranging the pairs in order of frequency of variation, the following sequence holds: 6th, 2d, 5th, 3d, 4th, 1st and inguinal. It is probable that the rank of the sixth is not significant, due to the lack of numbers in proportion to the others, but there is no question about the second pair being a leading seat of variation. In a former article on this subject the writer called attention to this fact without presenting figures. It is worth while noting that this variance in the second pair is perhaps not characteristic of swine as a whole, but simply due to the fact that both boars showed in this pair their variation from normal patterns.

The point of most frequent appearance of the triangular type is of interest, although possibly not significant. The rank is as follows:

	Per Cent.
Between 5th and 6th	16.09
Between 6th and 7th	4.023
Between 2d and 3d	3.25
Between 4th and 5th	2.7
Between 1st and 2d	2.2
Between 3d and 4th	1.23

Once more, if we discard the results between 5th and 6th, and 6th and 7th, because of small numbers, we find the high per cent. of variability at the second pair.

The point of appearance of the suppressed nipple variation was plotted in the same way and the following order of appearance was found:

	Per Cent.
6th pair	6.9
2d pair	6.3
5th pair	1.3
4th pair	1.1
3d pair	0.5
Inguinal pair	0.2
1st pair	0.0

Again the second pair is shown as the chief seat of variation. It may be well to mention that while there was a possibility of 1,138 mammæ appearing in the 1st, 2d, 3d, 4th, and inguinal pairs, only 704 mammæ could have appeared in the 5th pair and 174 mammæ in the sixth, because of the small numbers of animals having over ten and twelve mammæ, respectively.

No. Triangles	5 Prs.	6 Prs.	7 Prs.	*f*
1	4	53	23	79
2		8	10	18
3		2	1	3
4			1	1
f	4	63	35	101

Mean No. triangles = 1.267.
Standard deviation triangles = .5609.
Mean No. pairs mammæ = 6.3168.
Standard deviation pairs = .7889.
$r = .1666 \mp .065$.

Relation of Increased Pairs to the Common Variations.—A correlation was arranged between an increased number of pairs and the two common asymmetrical variations.

No. Suppressed Nipples	5 Prs.	6 Prs.	7 Prs.	f
1	1	91	24	116
2			9	9
	1	91	33	125

Mean of suppressed nipples = 1.072.
Standard deviation of suppressed nipples = .258.
Mean No. pairs = 6.256.
Standard deviation = .408.
$r = .5089 \pm .0447$.

While the correlation does not show a marked relation between the number of triangles and the increased number of mammæ, yet another method of plotting shows that there is a very significant relation between them and that the tendency to these variations may possibly be only a function of a large number of mammæ rather than a definitely heritable unit.

	No. of Pairs		
	5 Prs.	6 Prs.	7 Prs.
No. animals	217	296	56
No. each kind of animals with triangle	4	63	35
Per cent. animals of each class with triangle	1.84	21.28	62.5
No. animals of each class with suppressed mammæ	1	91	33
Per cent. animals of each class with suppressed mammæ	.46	30.74	58.93

The increased percentage of animals with the two types of variation among the animals with a larger number of mammæ speaks for itself.

This relation of the variations to the increased number of pairs, in connection with the fact that the variations appear most frequently in the pairs between the first, and inguinal, furnishes additional basis for the statement made earlier in the paper that the number of mammæ is increased by modifications between the first and inguinal pair.

Inheritance of the Two Forms of Variation.—The "triangles" show a marked degree of inheritance. Neither boar carried the triangular pattern somatically, but the offspring of the two were summarized separately to see if any difference developed in the offspring. Both boars possessed the "suppressed nipple" type, and, as might be expected, show little difference in breeding.

PIGS BY OLD BOAR

		Pigs with Triangle	Pigs with Suppressed Nipple	With Neither
Sows with triangle...........	No.	17	11	28
	Per cent.	30.00	20.00	50.00
Sows with suppressed nipple...	No.	2	14	26
	Per cent.	4.7	33.3	62.0
Sows with neither............	No.	45	60	169
	Per cent.	16.6	22.2	62.5

It is evident that a distinctly higher proportion of "triangles" appears in the pigs from sows of the same type. Also a distinctly greater percentage of pigs with the suppressed nipple comes from sows of the suppressed-nipple type, but the difference between the breeding character of the three classes of sows is not so marked with this variation, probably because the boar supplies the latter pattern with each mating.

PIGS BY YOUNG BOAR.

		Pigs with Triangle	Pigs with Suppressed Mamma	With Neither
Sows with triangle...........	No.	13	4	16
	Per cent.	39.394	12.121	48.485
Sows with symmetrical pairs...	No.	9	23	62
	Per cent.	9.574	24.468	65.957

Combining the two tables, there appears a result which may be more significant than in either when separate. In this table in the cases where a pig possesses both variations, he is listed twice, so that the percentage runs slightly over one hundred. There is one duplication from sows with the triangle and four duplications in the offspring of the "normal" sows.

		Pigs with Triangle	Pigs with Suppressed Mamma	With Neither
Sows with triangle	No.	30	15	44
	Per cent.	34.091	17.045	50.000
Sows with suppressed mamma	No.	2	14	26
	Per cent.	4.762	33.33	61.905
Sows with even pair	No.	54	83	231
	Per cent.	14.835	22.802	63.461

It is of interest to note that each form of variation appears in about one third of the offspring of the mothers that bear the same variation. Where the mother does not possess either type, the triangle appears in about one-seventh of the offspring and the suppressed mamma in one fourth. It is possible that a three-factor Mendelian ratio would account for the results, but since the factors are unknown it is scarcely worth while to present it.

Two of the sows possessed both the triangle and the suppressed mamma, and are not listed above. A close agreement with the preceding table may be noted.

	Pigs with			
	Triangle		Suppressed Mamma	Even Pairs
Sows with both variations	No.	15	1	10
	Per cent.	31.25	6.25	62.5

The constancy of the per cent. of even pairs in the two tables is undoubtedly worthy of notice. Neither boar possessed the triangle. Sows with the triangle produced 39 pigs with the triangle and 69 without. Sows without the triangle produced 56 pigs with it and 349 without. The character is apparently inherited as a distinct entity even though it may be merely a function of an increased number of mammæ. The sows without the triangle may be divided on their breeding performance into two groups. The first produced only offspring without triangles (124 pigs) while the second produced 56 pigs with triangles, 225 without. The proportions here look significant. In the first group the ratio of those possessing triangles to those without is about 1:2. In the second it is $O:N$ and in the third 1:4. The relative frequencies of these three groups also look promising: 124 (*O*:*N*):281 (1:4): 108 (1:2). The simple 1:2:1 ratio is approximated, although the excess of the second group is a little high. Records on next year's pigs are needed to prove the soundness of this method of division.

In a similar way the suppressed mammæ show a strong degree of inheritance. Both boars possessed the suppressed mamma pattern. Sows with the suppressed mamma produced 17 offspring with it and 49 without. Sows without it produced 94 with and 350 without. The ratios are approximately 1:3 and 1:3.7. Separating the sows without the character into two groups on the same basis as in the preceding case the following appears: 65 (1:3) from sows with the suppressed mamma, 388 (1:3) from sows without the suppressed mamma and 56 (*O*:*N*) from sows without the suppressed mamma. The frequencies look like two 3:1 ratios combined in which the two groups of three and one group of one are similar, but it is not the normal ratio of 7:1. This also may be only apparent, however, and another year's test is needed to throw more light on the subject. It is beyond doubt, nevertheless, that these two forms of variation are distinctly inherited and the manner of inheritance only is that which remains to be demonstrated.

Evidences of Segregation of the Two Types of Variation.—The grand-dams were plotted against their pigs of the 1912 litters and the correlations were figured in comparison with the dams. The results were not enlightening, as the following table shows.

Correlation between No. triangles in grand-dams and 1912 pigs	—.0064 ± .0624
Correlation between No. triangles in dams and 1912 pigs	.2241 ± .0592
Correlation between No. suppressed nipples in grand-dams and 1912 pigs	—.0966 ± .0618
Correlation between No. suppressed nipples in dams and 1912 pigs	—.0052 ± .0624

In the negative correlations the probable error is either approximately equal to the coefficient or else far larger, so that no emphasis can be placed on the result. In arranging them according to per cent. of offspring bearing the same variation the following is obtained:

	Per Cent. of Pigs with Supressed Nipple
Grand-dams without suppressed nipple	23.00
Dams without suppressed nipple	22.22
Grand-dams with suppressed nipple	11.76
Dams with suppressed nipple	11.11

No difference shows between the two classes, so it is possible that the presence of the variation in the boars tends to even things up.

	Per Cent. Pigs with Triangle
Grand-dams without triangle	15.31
Dams without triangle	10.47
Grand-dams with triangle	16.66
Dams with triangle	29.03

In the case of the triangle, the grand-dams without the variation have a higher per cent. of offspring possessing it than do the dams, but where the triangle is present in the dams and grand-dams the younger generation seems to have the greater power of transmission. Since the old boar previously mentioned is the sire of the dams, and the young boar the sire of the 1912 pigs, there has been no point of entrance for the triangle somatically. The percentages show some sort of segregation of a recessive character, but further matings are necessary to clarify the matter.

Variation in Number of Mammæ.—There is quite a wide range in the number of teats that may be present. The smallest number found in these litters is nine, while in the litters of last year, elsewhere reported, one pig appeared with only eight. The highest number recorded on one animal was sixteen, these including a pair of rudimentaries to the rear of the inguinal pair. Of the mammæ on the mammary lines of the abdomen fourteen is highest number.

The relative frequency of occurrence of these different numbers among the swine studied is shown in the following table:

	Number Mammæ					
	9	10	11	12	13	14
Number pigs	4	195	135	127	33	15
Per cent. frequency	0.78	38.31	26.52	24.95	6.48	2.95

Nearly 90 per cent (89.8) of the pigs bear ten, eleven or twelve mammæ, and may therefore be considered the normal types of the Duroc Jersey. In Bateson's data on Tamworth's and cross-bred Berkshires in his "Materials for the Study of Variation," he finds that twelve is the lowest number of mammæ occurring, fourteen is the mode and seventy-seven per cent. fall on thirteen, fourteen and fifteen. His numbers are much smaller (35), but it is highly probable that there is a difference in breeds as regards number of mammæ, particularly between those of bacon and lard type.

Correlation of Number of Mammæ between Dams and Pigs.—The coefficient of correlation for number of mammæ between the sows and pigs was not high (.2626 ± .028), yet it showed distinct inheritance. There was apparently no difference due to sex, as the boar pigs showed a correlation of .1734 ± .04 to their mothers, and the sow pigs were only slightly greater, .2133 ± .04. Since with the probable errors in consideration the two coefficients overlap, it seems doubtful if sex makes any difference in the inheritance.

Evidence of Segregation in Number of Mammæ.—The sows of the first generation were plotted against their grand-daughters giving the following results.

Grand-dams	Number of Mammæ of Pigs						
	9	10	11	12	13	14	Total
10		8	4	1			13
11	1	5	4				10
12		39	25	4			78
13		7	5	1			13
14		1			1	1	3
Total	1	60	38	16	1	1	117

Coefficient of correlation = .2962 ± .057.

The parents themselves showed a correlation to the offspring as follows:

Dams	No. Mammæ Pigs						
	9	10	11	12	13	14	Total
10	1	29	12	10			52
11		5	6				11
12		21	18	6			45
13		1			1	1	3
14		4	2				6
Total.......	1	60	38	16	1	1	117

Coefficient of correlation = .1418 ± .061.

The grandparents are much more closely correlated with the pigs (.2962 ± .057). Two explanations may be offered for this. Among the fifteen dams there were five pairs of sisters, so that there were only ten grand-dams to correlate. This would throw some of the litters into one class that were separated when correlated with the dams and so would modify the coefficient. An interpretation more satisfactory to the writer is that the higher coefficient between grand-dam and offspring represents the segregation of some mammary character the limits of which can not, at present, be defined.

Relation of Asymmetrical to Symmetrical Pattern.—An interesting point because of the constancy of the ratio lies in the relation of the symmetrical and asymmetrical patterns. In the pigs they occur in the ratio of 1:2, or 172 asymmetrical to 337 symmetrical. In the writer's paper of last year, already cited, the same ratio held and seemed unaffected by patterns in the parent. If divided according to sex, we find no difference, the boars showing 89 asymmetrical to 174 symmetrical and the sows showing 83 of the first to 163 of the second. The fact that both parents bear the asymmetrical pattern may influence the per cent. of asymmetry in the pigs, but this influence is very slight. Where boar and sows were asymmetrical the ratio was 50:85, while when the boar only was asymmetrical the ratio was 122:252. Putting them on the same basis, we find a ratio of 1:1.7 and 1:2.06. There may be significance in the difference between the two ratios, but the writer is inclined to think there is not, for last year's work gave 35 asymmetrical to 68 symmetrical pigs from two asymmetrical parents, and 33 to 62 from one asymmetrical parent.

Another method of plotting these ratios shows that differences may occur in connection with an increased number of pairs. When the animals have ten pairs, only four animals out of 199, or less than two per cent., show the variations. When the animals have six pairs, the number of animals having even pairs throughout are about equal with the number having the variation, 127 and 135, respectively. When the animals have seven pairs, the chances are about two to one that the animal will have one or the other variation (33:15). Placed on a percentage basis the following table results, showing that asymmetry is closely related to an increased number of pairs.

	Animals with		
	5 Prs,	6 Prs.	7 Prs.
No. animals	199	262	48
No. animals with the variations	4	135	33
Per cent. animals with the variations	2.01	51.52	68.75

Inheritance of Asymmetry.—The old boar possessed his asymmetrical nipple on the left side, the young boar on the right. The two boars were tabulated in their matings to sows possessed of each kind of asymmetry.

Old Boar (Extra Nipple on Left)

	Pigs with Extra Nipples	
	On Left	On Right
Sows with extra nipple on left	18	16
Sows with extra nipple on right	4	6
Symmetrical sows	45	47

Young Boar (Extra Nipple on Right)

	Pigs with Extra Nipples	
	On Left	On Right
Sows with extra nipple on left	3	9
Sows with extra nipple on right	0	1
Symmetrical sows	11	25

With the older boar no evidence of the inheritance of unilateral asymmetry is shown. With the younger boar, however, there is a distinct excess of pigs showing the asymmetry on the same side as the father. Since there is no means of telling from the external appearance what recessive characters the sow may be carrying, it is possible that there is a marked difference in the lateral predisposition of the two boars.

An examination of the offspring of asymmetrical and symmetrical sows shows a slight tendency toward the production of asymmetry in the offspring of that kind of parents. Eighteen sows of this type produced 96 pigs with even pairs and 74 without. Thirty-nine symmetrical sows produced 215 pigs with even pairs and 125 without. Using the asymmetrical pigs as the base, the first ratio is 1:1.297 and the second is 1:1.72. While we are justified in assuming a degree of inheritance of asymmetry, we are not yet able to show the same by definite units.

Is Inheritance Lateral or by Pairs?—The embryological origin of the mammary tissue suggests that there may be a lateral inheritance. In order to determine this, the right side of the mother was correlated with both the right and left sides of the offspring, and the left side of the mother correlated in the same way. The offspring of the two boars were separated, since the old boar had six teats on the left side and five on the right, while in the young boar this relation was reversed.

The results were disappointing if one expected a high correlation.

	Pigs by Young Boar	Pigs by Old Boar
Right side dam to right side pig	.1196 ± .0353	.1601 ± .0346
Right side dam to left side pig	.0384 ± .0353	.2326 ± .0346
Left side dam to right side pig	—.0023 ± .0353	.1436 ± .0346
Left side dam to left side pig	—.0296 ± .0353	.2132 ± .0346

In the last three correlations in the pigs by the young boar, the probable error equals or exceeds the correlation, and in the pigs by the old boar, the probable error permits the correlations to just about meet each other or even overlap. In the pigs by the young boar the correlation between the same sides of sow and offspring exceeds that of the opposite sides, but in the offspring of the old boar the left side of the pig is more closely correlated to either side of the mother than is the right side of the pig. These contradictions lead the writer to believe that the inheritance is not lateral.

All of the offspring were tabulated as to number of pairs against their dams and the correlation was determined. The coefficient is .1994 ± .028, large enough to show some inheritance. As the animals included here possess the two common types of variation, or were from dams possessing those types, a second table was prepared of pigs with symmetrical pairs from sows of the same type. A larger coefficient resulted, .3588 ± .039, but even this is not satisfactory, as the boars possess the suppressed nipple, and of course, the offspring represent a selected group, although not selected from a standpoint that should favor the correlation.

Another method of tabulating may show the inheritance more graphically. The boars have six pairs, with one mamma suppressed.

No. Pairs in Sow	Av. for Offspring All Individuals	Av. for Symmetrical Individuals
5	5.57	5.27
6	5.76	5.48
7	5.90	5.65

There is a distinct increase in the means of the offspring as the number of pairs increases in the parent. The mating of the boars to the sows with the following number of mammæ is interesting:

Boars	Sows	Pigs with 5 Prs.	6 Prs.	7 Prs.
6 prs.	5 prs.	69	60	2
6 prs.	6 prs.	103	162	34
6 prs.	7 prs.	28	40	12

This corroborates the results above.

The foregoing tables lead the writer to believe that the method of inheritance is by the pair rather than the side, although the determination of the pair as a Mendelizing unit must be deferred until further study is made.

Rudimentaries in the Abdominal Series.—Bateson looks on rudimentaries that occur asymmetrically in the abdominal series of mammæ, as a sort of supernumerary organ systematically and different qualitatively from the normal mammæ. He so classifies them because of their visible differences and because of their ability to displace normal mammæ from the ordinary paired state. It seems to the writer that while this distinction may be all right from Bateson's standpoint, from the standpoint of heredity it is without weight. The factor that causes the transverse sectioning of the strips of mammary tissue is obviously separate from the forces that cause development of the glands. This factor operates irrespective of whether the gland be destined to develop or not, and it is very evidently this factor (probably complex) that is inherited.

At birth or shortly after it is difficult to tell whether a mamma will develop functionally or not. There are some that are so small and undeveloped that one may be positive as to their rudimentary state throughout life, but there are others for which prediction is very uncertain. The writer has left all doubtful cases out of consideration and has figured asymmetry due to a rudimentary nipple in relation to asymmetry produced by developed teats.

There are 89 asymmetrical males. One of these is asymmetrical from the presence of a rudimentary; two more possess a rudimentary each, but are asymmetrical through the presence of functional "triangles"; and two symmetrical boars possess rudimentaries as one member of a pair. It must be understood in connection with the foregoing that all of the mammæ of the male are really rudimentary, and that what the writer has termed rudimentary in the preceding statement refers to mammæ that are so much smaller as to occupy a relation similar to the rudimentary and normal mammæ in the young female.

Eighty-three asymmetrical sows show only one individual whose asymmetry is due to the presence of a rudimentary. One sow has a rudimentary, but is asymmetrical from a functional "triangle," and one symmetrical sow shows a rudimentary in one of her pairs.

Summarized this shows that only 1.123 per cent. of the asymmetrical males have their asymmetry caused by rudimentaries, and only 1.204 per cent. of the females. From this evidence it would seem that rudimentaries do not represent a step in the variation of the mammary linear series, but from the standpoint of heredity should be treated the same as normal teats, the lack of development being probably due to fluctuating somatic causes.

It is interesting to compare the variability of the nipples of the male, which are rudimentary throughout life, with the teats of the female, which are potentially functional. The coefficient of variability for the boar pigs is .1009 ± .003 and for the sow pigs it is .0943 ± .0028. The probable error permits a minimum separation of the two coefficients of only .0008, so that the difference between the two is probably not significant. In the litters of 1911, already referred to, the boar pigs were slightly more stable than the sows, which would further argue against a qualitatively constant significant difference.

The Rudimentaries to the Rear of the Inguinal Pair.—In the previous discussion no account has been taken of a pair of rudimentaries which occur on the lower forward part of the scrotum of the male, and well to the rear on the inner thighs of the female. The pair is entirely distinct from the others, and readily recognizable from its location and also from the fact that so far as the writer has observed it is always rudimentary. It seems probable that it lacks almost entirely the backing of mammary tissue found in the other mammæ. The writer has already described the inheritance of the character in another paper, so will simply summarize the results. The pair behave as a Mendelian unit character in heredity, dominant in males but recessive in females. That is, it is developed somatically in the male when either simplex (*Rr*) or duplex (*RR*), but develops in the female only in the duplex (*RR*) condition. The boars used were simplex from their behavior in breeding, while the sows embodied all three types.

BOAR (*Rr*)

Low Type	No. Sows		Boar Pigs		Sow Pigs	
			Absent	Present	Absent	Present
RR	9	Expectation	0	39	20	20
		Actual	0	39	27	13
		Expectation	17	51	66	22
Rr	16	Actual	23	44	64	24
		Expectation	60	60	95	0
rr	24	Actual	66	54	95	0

Fifteen of those recorded in the first two columns were daughters of some of the remaining. In each case the gametic composition assigned the young sows from their breeding performance confirmed the formula assigned the mother. There is some variation from the expectation particularly in the female pigs from the *RR* sows and the male pigs from the *Rr* mothers. The numbers are too small to permit of the deviation being significant, however, and the departure from expectation in the sow pigs in the first instance shows that the rudimentaries are not a distinctly feminine character. Attention should be called to the fact that in the male the deviations from expectation are on the same side.

The following table was plotted to see if the rudimentaries are a function of an increased number of mammæ, similar to the two common types of variation.

	Number of Mammæ per Animal					
	9	10	11	12	13	14
No. animals	4	181	131	135	36	16
No. animals with rudimentaries	3	59	58	52	10	1
Per cent. latter	75.00	32.59	44.28	38.52	27.77	6.25

The fluctuating percentages in connection with the fact that the two lowest percentages are recorded against the highest numbers of mammæ, would incline the writer to believe that the rudimentary mammæ of the scrotum and thigh are independent of the abdominal series, and furthermore that the Mendelian interpretation is correct.

Conclusions.—I. There are two common sorts of variation from the even paired type in the mammæ of swine, aside from the simple addition and subtraction of pairs. These are the "triangle" and "suppressed" nipple variations. Each shows a definite tendency to reproduce itself in the offspring, but both are apparently associated with an increased number of pairs.

II. The seat of the greatest variation in the animals under discussion is the second pair of mammæ. This is perhaps due to the type of variation in the sires.

III. There is apparently a breed difference in regard to the number of mammæ. Bateson shows that in Tamworths and Berkshires, 13, 14 and 15 mammæ are typical, occurring in 77 per cent. of the cases. The Duroc Jerseys studied show in 90 per cent. of the animals, 10, 11 or 12 mammæ.

IV. The ratio of asymmetrical to symmetrical patterns increases as the number of mammæ increase. With five pairs symmetry is almost constant; with six pairs, symmetry and asymmetry are equal. With seven pairs asymmetry outnumbers symmetry 2 to 1.

V. No evidence definitely showed that asymmetry is unilateral in inheritance. Asymmetry on one side of the parent does not, on the average, produce asymmetry on the same side only of the offspring.

VI. Sows differing in number of mammæ, when mated with the same boar, produce offspring variable in number of mammæ. In general, sows with a large number of mammæ produce more offspring of a corresponding sort than do sows with a small number of mammæ. The difference, however, is not great, and neither sort apparently breeds true. The correlation of mother and offspring in number of mammæ is measured by the coefficient .2626 ± .028.

VII. There is a distinct inheritance of the tendency to produce a greater number of pairs, the correlation being .3588 ± .034.

VIII. There is no evidence of lateral inheritance of the mammæ, the inheritance by pairs being a more probable hypothesis.

IX. No definitely Mendelizing units were found in the abdominal mammary series, but the relations between grandparents and offspring and parents and offspring, do indicate a segregation of some sort.

X. Rudimentaries in the functional mammary series have the same effect on the pattern as normal mammæ, and probably represent lack of development. There is no greater tendency to variation among the rudimentary nipples of the male than among the potentially functional nipples of the female.

XI. The paired rudimentaries to the rear of the inguinal pair behave as a simple Mendelian unit-character, sex-limited in inheritance.

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